

the only type that can withstand extended exposure (more than 10 min) to high-temperature air or to fire inside or outside the duct.

Individual filter supports are recommended. The use of temporary supports on upper filters is sometimes necessary to permit replacement of one of the lower filters. As with open-face filters, horizontal airflow through enclosed filters is recommended.

The enclosed HEPA Filter design is not intended or recommended to replace or serve as a containment housing. When disconnecting the enclosed filter from the ductwork, extreme caution and care must be taken to minimize the contamination leakage that can occur before the filter is suitably bagged and sealed for handling.

6.4 CYLINDRICAL FILTER ELEMENTS

The cylindrical HEPA filter is another configuration that often appears to offer ideal solutions to certain installation requirements. However, this type of filter must be used with caution because of shortcomings in its construction. One manufacturer makes a spiral of the filter material and a separator; the others make a conventional pleated-medium-and-separator core that is trimmed to a cylindrical shape. In both designs, the core is slipped into a molded or welded-seam cylinder and sealed by catalyst-activated plastic foam or an adhesive as shown in **FIGURE 6.22**. There is no interference or pressure fit between core and casing, as in the open-face and enclosed rectangular configurations, because the core would be damaged when fitted into the case. In addition, because the cases are often made from light-gage, easily deformed sheet metal, they are often considerably “out-of-round.” The result is often a filter element that leaves much to be desired in the areas of leak integrity after a period of service and resistance to the exigencies of air cleaning system service.

Cylindrical HEPA filters can be obtained with or without flanges on one or both ends. The filters without flanges are used in push-through (so-called incessant) installations as shown in **FIGURE 6.23**. The filters are sealed into a cylindrical opening with one or more half-round



Figure 6.22 – Welded seam cylinder

circumferential gaskets (fixed to the filter), which make a slight interference fit with the receiver. As the filters are often out-of-round and a reliable interference fit between filter and receiver is impracticable, push-through installations are often unreliable under system-upset conditions. Push-through filters are subject to being blown out of the receiver if pressure differentials become high. Flanged cylindrical HEPA filters as shown in **FIGURE 6.24** can be installed in pipe openings by bolting them to a flange on the pipe or by clamping the filter flange between mating pipe flanges. Conventional neoprene sponge gaskets are used for sealing (see Section 4.4.6). Because filter flanges and cases are characteristically made from light-gage sheet metal with the flange seal-welded to the cylinder, these filters often leak at the flange-to-case weld. The flange also often becomes deformed. Either condition results in an installation that is difficult to seal.



Figure 6.23 – Cylindrical HEPA filter



Figure 6.24 – Flanged cylindrical HEPA filter

Cylindrical HEPA filters cost substantially more than rectangular HEPA filters of equivalent airflow capacity. There are no standard dimensions or airflow capacities, and those listed in the manufacturer's catalogs are generally simply those that have been special-ordered by another purchaser at an earlier date. No cylindrical filters are listed in any of the standard specifications for HEPA filters (e.g., ASME AG-1,⁴ DOE-STD-3020-97,¹³ IEST-RP-CC001.3⁸). Cylindrical HEPA filters are characteristically of relatively small diameter (less than 12 in.) and airflow capacity. The authors know of only one 1,000-cfm cylindrical HEPA filter installation. In this case the filter was installed horizontally with downward airflow; and it had to be replaced frequently because of mechanical damage resulting from high moisture loadings, the unfavorable filter configuration, and unfavorable installation practices. The operator eventually replaced the cylindrical filter with open-face rectangular units that could be bought from stock at a fraction of the price of the special cylindrical elements.

There are two methods of installing cylindrical filters, one a duct-entrance design and the other a hot-cell exhaust design. In the hot-cell exhaust design, the mounting is sloped to permit runoff of any liquid accidentally spilled on the shield that protects the filter and to facilitate handling by the cell electromechanical manipulators. Where cylindrical HEPA filters are used, liberal clearance (at least 1/8-in. all around) between the case and receiver is necessary to accommodate the characteristic out-of-roundness, see **FIGURE**

6.25. The advantage of cylindrical filters is close conformance to round ducts and pipes, which can permit the use of smaller, cheaper duct transitions and require less space. For in-line installations, however, except where the filter has flanges on both faces and is installed as a spool piece, provision must be made to extract the filter from the duct or pipe after the connection is broken, with the result that the space advantage over an equivalent open-face rectangular filter may be lost. Spool-piece filters must have flanges that can withstand the forces imposed by the duct or piping system and the flange bolting.

Cylindrical filters are often used in radioactive vacuum cleaners and portable air purifiers (**FIGURE 6.26**). The air purifier shown is a single-use device that is discarded when the contamination level or pressure drop of the collectors becomes greater than some pre-established design level or the arresting efficiency of the collectors drops below a pre-established design level (usually 99.97 percent for the filter). The air purifier was provided to clean a low-volume flow of off-gas evolved during the processing of high-level transcurium elements.⁶ Although an open-face rectangular filter element could have been used in a somewhat different arrangement, use of the cylindrical element was a designee's option, not a requirement of the application. As a general rule, use of the rectangular filter is recommended wherever practicable.



Figure 6.25 – Clearance Between Filter and Housing



Figure 6.26 – Cylindrical filter air purifier

6.5 INSTALLATION

6.5.1 HUMAN FACTORS

The recommendation to install filters vertically, with horizontal airflow, is discussed in Chapter 4. When practicable, single-filter installations should be located where they can be reached for service and testing without workers having to climb ladders or scaffolding. This requires a consideration of human engineering factors, i.e., the reaching and lifting capability of the average man. The reaching and lifting dimensions of female workers are substantially smaller.⁷ Analysis of the recommended weight limits indicates that handling a 1,000-cfm HEPA filter in the body positions often encountered in filter-change operations is at the upper range of personnel capability (higher loadings result in lower man-efficiency) and that handling of adsorber cells is well beyond the limits for one person.

Consideration must be given to the positions that a worker must assume to perform the required task. If the worker must hold his hands overhead for any length of time, fatigue may result. If crouching, bending, or squatting is required, the worker will soon become stiff, which will contribute to a loss of efficiency. If a worker has to hold a heavy weight while performing a precision operation (e.g., supporting the weight of a filter or adsorber cell while trying to fit it between duct transitions or into a restricted opening), the stress of the combined task will become fatiguing and a mistake is likely to occur.⁷ All of these factors are compounded when the worker must wear protective clothing and respiratory protection. In addition, protective clothing adds to the worker's spatial requirements and limits mobility. For HEPA filter and adsorber cell installations, location of the filter or housing at an elevation between knee and shoulder height is recommended.

6.5.2 FUME HOOD FILTER INSTALLATIONS

The wide, often unpredictable variety of chemical operations conducted in laboratory fume hoods makes the selection and installation of HEPA filters difficult and uncertain. Corrosive fumes may damage the filter and its mounting, and moisture and heat from hood operations may accelerate the damage. Operations that produce steam or moisture should be restricted to minimize condensation in, or the carry-over of water and/or chemical droplets to, the filter core.

Some facilities install the fume hood filters in the attic, usually directly above the hood served. Where such a design is employed, the attic space should be designed as a contamination zone for easy cleanup in the event of a spill, and should not be used for extraneous purposes such as storage and experimental work when radioactive materials are handled in the hood.

Hoods in which perchloric acid and certain other chemicals are handled should be provided with wash-down facilities to permit periodic decontamination of the hood and ductwork (perchloric acid hoods should not be used for handling other materials because of the explosion hazard). Off-gas scrubbers are often provided in hoods. Both wash-down facilities and scrubbers generate substantial quantities of sensible water